REMARKS/ARGUMENTS

In the Office Action, the drawings were accepted by the Examiner but rejected by the Draftsperson in a PTO-948. A set of the Examiner's approved drawings meeting the formal requirements of the PTO-948 were submitted previously. A further amendment to Figs. 1 and 4 are presented on replacement sheets to correct an error (an omitted arrow-head).

Objections were made to various claims (Point 4 of the Office Action) and claim 17 was rejected under 35 USC 112 (first paragraph) for reasons set forth in the Action.

Claims 1, 4, 11, 13, 15 and 17 were rejected under 35 USC 102(b) as being anticipated by Kobayashi et al, US 5,853,328 (Kobayashi) for the reasons stated in point 6 Pages 3-4. Claims 4 and 15 were rejected under 35 USC 102(b) as being anticipated by Parker US 2,124,006 for the reasons stated in point 7 Page 4 of the Office Action. Claims 4 and 15 were rejected under 35 USC 102(b) as being anticipated by Hendrickson US 1,149,762 for the reasons stated in point 8 Page 5 of the Office Action. Claims 1, 4, 11, 13, 15 and 17 were rejected under 35 USC 102 (e) as being anticipated by Pritschow et al, US 5,916,328 for the reasons stated in point 9 Page 5 of the Office Action.

The following argument is presented to distinguish the claims, as amended, from the cited art, thereby to overcome the rejections and to secure allowable subject matter in the claims.

The claims have been amended to set forth the invention more accurately and clearly so as to overcome the rejection under 35 USC 112, first paragraph, and also the objections raised against the claims.

An important aspect of the link mechanism of the present invention is that the link mechanism is for a surgical assist apparatus in the presence of an electromagnetic field of magnetic resonance and therapy.

In MR/T (magnetic resonance and therapy), fusion of diagnosis and treatment, it is necessary that the presence and function of medical equipment do not generate artifacts (such as noise and ghosts) on an image produced by the equipment.

It is therefore difficult to use a complex mechanism, active mechanical elements such as motors, and various types of sensors, The link mechanism of this invention can be composed from substantially only two spherical bearings and one axial rod. These components can be made of paramagnetic material having small magnetic susceptibility, such as ceramics, glass fiber reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal. Active mechanic elements and sensors are not essential. Therefore this link mechanism is excellent in MR compatibility, is detachable, cleanable and sterilizable, and can

be employed for a surgical assist apparatus in the presence of an electromagnetic field of MRT.

The mechanism of the present invention has a high precision of position and angle determination, does not require strong actuators, and is mechanically simple and easy to use with respect MR compatibility, cleaning and sterilization, and provides a benefit in which an end effector does not intercept the field of view of the surgeon. Therefor the link mechanism of the present invention is excellent and in use for surgical assist apparatus with MR/T.

The cited art does not disclose the foregoing aspects of the present invention.

The independent claims have been amended to insert the foregoing feature into the claims, thereby to overcome the rejections under 35 USC 102, and secure allowable subject matter. These features are disclosed on pages 1 (first two paragraphs) 6 (last paragraph) of the present specification.

The most distinctive feature of the present invention is that, the apparatus and method of the present invention relate to the link mechanism for surgical assist robot. Surgical assist robot for MR/T must realize a mechanism to determine at least the position (x, y, z,) and angles θ and φ to define the direction in 3 dimensional space. It is also desired that the end effector is cleanable and sterilizable. The end effector is also required to

be simple and compact so as not to intercept the view field and the work area of the surgeon. In addition, the output power of actuator should be as small as possible to maintain safety.

The link mechanism of this invention can be composed from substantially only two spherical bearings and one axial rod. These components can be made of paramagnetic material having small magnetic susceptibility, such as ceramics, glass fiber reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal. Active mechanical elements and sensors are not essential. This link mechanism is excellent in MR compatibility, detachable, cleanable and sterilizable. In addition to the above, two spherical bearings/supports are driven by drivers respectively when they change their positions.

In contrast to the present invention, Kobayashi relates power transmission device and constant velocity universal joint, thereof, but it does not relate to a link mechanism of a robot. Further it does not disclose a driver (actuator) which drives two spherical bearings.

Pritschow teaches a divice for a platform of so-called Octahedral machine with six telescopic legs, but it does not relate link to the mechanism of a robot. Further it does not disclose a driver (actuator) which drives two spherical bearings.

Hendrickson relates to a supporting member for music instruments, but it does not relate to the link mechanism of robot. Further it does not disclose a driver (actuator) which drive two spherical bearings.

Parker relates to a dial test indicator, but it does not relate link mechanism of robot. Further it does not disclose a driver (actuator) which drives two spherical bearings.

All of the claims are believed to be allowable in view of the foregoing argument.

In the event there are further issues remaining the Examiner is respectfully requested to telephone attorney to reach agreement to expedite issuance of this application.

The withdrawn claims are to be canceled subsequent to an indication of allowable subject matter.

Since the present claims set forth the present invention patentably and distinctly, and are not taught by the cited art either taken alone or in combination, this amendment is believed to place this case in condition for allowance and the Examiner is respectfully requested to reconsider the matter, enter this amendment, and to allow all of the claims in this case.

Respectfully submitted,
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by:____________
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CERTIFICATE OF MAILING UNDER 37 CFR SECTION 1.8(a)

I hereby certify that the accompanying Amendment is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patent, P.O. Box 1450, Alexandria 22313-1450, on January 21, 2005.

Dated: January 21, 2005

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AMENDMENTS TO THE DRAWINGS

Each of Figures 1 and 4 is amended further by inclusion of an arrow head adjacent a bearing P_2. Presented in a Replacement Sheet. For convenience, in observing the arrow head an annotated sheet is provided with the location of the arrow head being indicated. The arrow head is shown in the originally filed set of drawing figures.

wherein said rod and each of said spherical bearings constructed of material drawn from a class of paramagnetic materials of small magnetic susceptibility including ceramic material, glass fiber-reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal, said material permitting use of the robot for magnetic resonance and therapy applications in an environment of an electromagnetic field without generation of artifacts in images produced by magnetic resonance and therapy applications.

2. (withdrawn) Method to determine a position and a direction of an axial rod of a link mechanism wherein, said link mechanism comprises:

an axial rod; and

two spherical bearings to support said axial rod, said two spherical bearings being capable of changing positions, wherein the method comprises steps of:

constraining a motion of one of said two spherical bearings relative to said axial rod along the axis of said axial rod;

allowing the other of said spherical bearings to travel along said axial rod; and

determining the position and direction of said axial rod by defining a coordinate value of one of said two spherical bearings and a position of the other of said two spherical bearings relative to the one of said two spherical bearings.

3. (withdrawn) A method to determine a position and a direction of an axial rod according to claim 2, wherein the link mechanism is for an output of a robot.

4. (currently amended) A link mechanism for <u>a</u> surgical assist robot to determine a position and a direction of an axial rod, comprising:

an axial rod; and

two supports to support said axial rod, said two supports being capable of changing positions,

wherein a motion of one of said two supports relative to said axial rod along an axis of said axial rod is constrained, and the other of said supports can travel along said axial rod <u>; and</u>

<u>wherein said rod and each of said spherical bearings constructed of material drawn from a class of paramagnetic materials of small magnetic susceptibility including</u>

ceramic material, glass fiber-reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal, said material permitting use of the robot for magnetic resonance and therapy applications in an environment of an electromagnetic field without generation of artifacts in images produced by magnetic resonance and therapy applications.

5. (withdrawn) Method to determine a position and a direction of an axial rod of a link mechanism wherein, said link mechanism comprises:

an axial rod; and

two supports to support said axial rod, said two supports being capable of changing positions,

wherein the method comprises steps of:

constraining a motion of one of said two supports relative to said axial rod along the axis of said axial rod;

allowing the other of said supports to travel along said axial rod; and

determining the position and direction of said axial rod by defining a coordinate value of one of said

two supports and a position of the other of said two supports relative to the one of said two supports.

6. (withdrawn) A method to determine a position and a direction of an axial rod according to claim 5, wherein the link mechanism is for an output of a robot.

7. (withdrawn) Method for establishing the position of a second spherical bearing of a link mechanism relative to a first spherical bearing of the mechanism, and for establishing the direction, relative to a rod of the mechanism, of an arm segment extending from said second bearing, the method comprising:

attaching said spherical bearings to said rod, and enabling said two spherical bearings to change positions relative to each other along said rod;

wherein motion of one of said two spherical bearings relative to said rod along an axis of the rod is constrained, and the other of said spherical bearings can travel along said rod; and the method further comprises a step of

defining coordinate values of one of said two spherical bearings and the position of the other of said two spherical bearings relative to the one of said two spherical bearings.

8. (withdrawn) Method according to claim 7, wherein the link mechanism serves as an output of a robot.

9. (withdrawn) Method for establishing the position of a second support of a link mechanism relative to a first support of the mechanism, and for establishing the direction, relative to a rod of the mechanism, of an arm segment extending from said second support, the method comprising:

attaching said supports to said rod, and enabling said two supports to change positions relative to each other along said rod;

wherein motion of one of said two supports relative to said rod along an axis of the rod is constrained, and the other of said supports can travel along said rod; and the method further comprises a step of

defining coordinate values of one of said two supports and the position of the other of said two supports relative to the one of said two supports.

10. (withdrawn) Method according to claim 9, wherein the link mechanism serves as an output of a robot.

11. (currently amended) A link mechanism for a surgical assist robot to determine a position and direction of an axial rod of robotic equipment, the link mechanism serving to direct a manipulator of a robot to determine the position and direction of a surgical assist apparatus in the presence of an electromagnetic field of magnetic resonance and therapy equipment, wherein the manipulator has a configuration to minimize magnetic susceptibility and electrical noise radiation, the link mechanism comprising:

an axial rod; and

two spherical bearings engaging with said axial rod, a second bearing of said two spherical bearings being capable of changing positions relative to a first bearing of said two spherical bearings along said axial rod, wherein said robot has a first manipulator extending from ~~a~~ said first of said spherical bearings and a second manipulator extending from ~~a~~ said second of said spherical bearings to engage the surgical assist apparatus while minimizing interaction with said electromagnetic field; and

wherein a motion of said first spherical bearing relative to said axial rod along an axis of said axial rod is constrained, and said second spherical bearing can travel along said rod to enable a drive mechanism of the robot to position and to direct each of said first and said second manipulators ; and

wherein said rod and each of said spherical bearings constructed of material drawn from a class of paramagnetic materials of small magnetic susceptibility including ceramic material, glass fiber-reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal, said material permitting use of the robot for magnetic resonance and therapy applications in an environment of an electromagnetic field without generation of artifacts in images produced by magnetic resonance and therapy applications.

12. (withdrawn) A method to determine a position and a direction of an axial rod of a link mechanism in robotic equipment, the link mechanism serving to direct a manipulator of a robot to determine the position and direction of a surgical assist apparatus in the presence of an electromagnetic field of magnetic resonance and therapy equipment, wherein the manipulator has a configuration to minimize magnetic susceptibility and electrical noise radiation, the manipulator comprising:

an axial rod; and

two spherical bearings engaging with said axial rod, said two spherical bearings being capable of changing positions relative to each other along said axial rod, wherein said robot has a first manipulator extending from a first of said spherical bearings and a second manipulator extending from a second of said spherical bearings to engage the surgical

assist apparatus while minimizing interaction with said electromagnetic field, wherein the method comprises steps of:

constraining a motion of one of said two spherical bearings relative to said axial rod along the axis of said axial rod;

allowing the other of said spherical bearings to travel along said rod to enable a drive mechanism of the robot to position and to direct each of said first and said second manipulators; and

determining the position and the direction of said axial rod by defining a coordinate value of one of said two spherical bearings and a position of the other of said two spherical bearings relative to the one of said two spherical bearings.

13. (currently amended) A link mechanism for a surgical assist robot to determine a position having coordinates (X_1, Y_1, Z_1) and a direction having coordinates (θ, φ) of an axial rod (R) for robotic equipment works in the robotic workspace, the link mechanism comprising:

an axial rod (R); and

~~two~~ first and second spherical bearings (P_1 and P_2) engaging with said axial rod (R), said first

spherical bearing (P_1) having said position coordinates (X_1, Y_1, Z_1), and said second spherical bearing (P_2) being capable of changing its position identified by coordinates (x', y', z') derived from an equation (1) relative to said first spherical bearing (P_1) along said axial rod (R), wherein

$$
\begin{aligned}
x' &= r \cos \varphi \sin \theta \\
y' &= r \sin \varphi \sin \theta \\
z' &= r \cos \theta \qquad (1)
\end{aligned}
$$

wherein said first spherical bearing (P_1) is capable of being driven to change <u>the</u> position of the rod in three-dimensional space by a driver and said second spherical bearing (P_2) is capable of being driven to change <u>the</u> position in three dimensional space or a two dimensional plane relative to said first spherical bearing (P_1) by a driver, said robot has said robotic equipment mounted on said axial rod (R); and the length of the axial rod (R) should be longer than the maximum length of r, and

wherein a motion of said first spherical bearing (P_1) relative to said axial rod (R) along of said axial rod (R) is constrained, and said second spherical bearing (P_2) can travel along said axial rod (R) to enable <u>a positioning</u> and <u>a directing of</u> said axial rod (R) and said robotic equipment, wherein:

r: distance between P_1 and P_2 along the axis of axial rod (R)

x_2: coordinate value of P_2 along the x axis of xyz coordinate

y_2: coordinate value of P_2 along the y axis of xyz coordinate

z_2: coordinate value of P_2 along the z axis of xyz coordinate

x_1: coordinate value of P_1 along the x axis of xyz coordinate

y_1: coordinate value of P_1 along the y axis of xyz coordinate

z_1: coordinate value of P_1 along the z axis of xyz coordinate

θ: angle of R measured from x axis of x-z plane

Φ: angle of R measured from y axis of y-z plane

$x' = x_2 - x_1$

$y' =$ [[$Y_2 - Y_1$]] $y_2 - y_1$

$z' = z_2 - z_1$

$r^2 = x'^2 + y'^2 + z'^2$; and

wherein said rod and each of said spherical bearings constructed of material drawn from a class of paramagnetic materials of small magnetic susceptibility including ceramic material, glass fiber-reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal, said material permitting use of the robot for magnetic resonance and therapy applications in an environment of an electromagnetic field without generation of artifacts in images produced by magnetic resonance and therapy applications.

14. (withdrawn) A method to determine a position (X_1, Y_1, Z_1) and direction (θ, φ)) of an axial rod (R) for robotic equipment works in the robotic workspace, the link mechanism comprising:

an axial rod (R); and

two spherical bearings (P_1 and P_2) engaging with said axial rod (R), said first spherical bearing (P_1) being capable of changing position into (X_1, Y_1, Z_1) and said second spherical bearing (P_2) being capable of changing position into(X', Y', Z') derived from equation (1) relative to said first spherical bearing (P_1) along said axial rod (R),

$$x' = r \cos \varphi \sin \theta$$
$$y' = r \sin \varphi \sin \theta$$
$$z' = \cos \theta \qquad (1)$$

wherein said first spherical bearing (P_1) being capable of being driven to change position in 3D space by driver and said second spherical bearing (P_2) being capable of being driven to change position in 3D space or 2D plane relative to said first spherical beating (P_1) by driver, said robot has said robotic equipment mounted on said axial rod (R); and the length of the axial rod (R) should be longer than the maximum length of r, and

wherein a motion of said first spherical bearing (P_1) relative to said axial rod (R) along of said axial rod (R) is constrained, and said second spherical bearing (P_2) can travel along said axial rod (R) to enable to position and to direct said axial rod (R) and said robotic equipment,

Wherein:

r: distance between p_1 and P2 along the axis of axial rod (R)

x_2: coordinate value of P_2 along the x axis of xyz coordinate

y_2: coordinate value of p_2 along the y axis of xyz coordinate

z_2: coordinate value of p_2 along the z axis of xyz coordinate

x_1: coordinate value of p_1 along the x axis of xyz coordinate

y_1: coordinate value of p_1 along the y axis of xyz coordinate

z_1: coordinate value of p_1 along the z axis of xyz coordinate

θ: angle of R measured from x axis of x-z plane

Φ: angle of R measured from y axis of y-z plane

$x' = x_2 - x_1$

$Y' = Y_2 - Y_1$

$z' = z_2 - z_1$

$r^2 = x'^2 + y,^2 + z'^2$

15. (currently amended) A link mechanism for a surgical assist robot to determine a position having coordinates (X_1, Y_1, Z_1) and a direction having coordinates (θ, φ) of an axial rod (R) for robotic equipment works in the robotic workspace, the link mechanism comprising:

an axial rod (R); and

~~two~~ first and second supports (P_1 and P_2) engaging with said axial rod (R), said first support (P_1) having said position coordinates (X_1, Y_1, Z_1) and said second support (P_2) being capable of changing its position identified by coordinates (x', y', z') derived from an equation (1) relative to said first support (P_1) along said axial rod (R), wherein

$$x' = r \cos \varphi \sin \theta$$

$$y' = r \sin \varphi \sin \theta$$

$$z' = r \cos \theta \qquad (1)$$

wherein said first support (P_1) is capable of being driven to change position of the rod in three-dimensional space by a driver and said second support (P_2) is capable of being driven to change position in three dimensional space or a two dimensional plane relative to said first support (P_1) by a driver, said robot has said robotic equipment mounted on said axial rod (R); and the length of the axial rod (R) should be longer than the maximum length of r, and

wherein a motion of said first support (P_1) relative to said axial rod (R) along of said axial rod (R) is constrained, and said second support (P_2) can travel along said axial rod (R) to enable ~~to position~~ a positioning and a directing of ~~to direct~~ said axial rod (R) and said robotic equipment,

Wherein:

r: distance between [[p_1]] P_1 and P_2 along the axis of axial rod (R)

x_2: coordinate value of P_2 along the x axis of xyz coordinate

y_2: coordinate value of P_2 along the y axis of xyz coordinate

z_2: coordinate value of P_2 along the z axis of xyz coordinate

x_1: coordinate value of P_1 along the x axis of xyz coordinate

y_1: coordinate value of P_1 along the y axis of xyz coordinate

z_1: coordinate value of P_1 along the z axis of xyz coordinate

θ: angle of R measured from x axis of x-z plane

Φ: angle of R measured from y axis of y-z plane

$x' = x_2 - x_1$

$y' = y_2 - y_1$

$z' = z_2 - z_1$

$r^2 = x'^2 + y'^2 + z'^2$; and

wherein said rod and each of said spherical bearings constructed of material drawn from a class of paramagnetic materials of small magnetic susceptibility including ceramic material, glass fiber-reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal, said material permitting use of the robot for magnetic resonance and therapy applications in an environment of an electromagnetic field without generation of artifacts in images produced by magnetic resonance and therapy applications.

16. (withdrawn) A method to determine a position (X_1, Y_1, Z_1,) and direction (θ, φ) of an axial rod (R) for robotic equipment works in the robotic workspace, the link mechanism comprising:

an axial rod (R); and

two supports (P_1 and P_2) engaging with said axial rod (R), said first support (P_1) being capable of changing position into (X_1, Y_1, Z_1,) and said second support (P_2) being capable of changing position into(X', Y', Z') derived from equation (1) relative to said first support (P_1) along said axial rod (R),

$x' = r \cos \varphi \sin \theta$

$y' = r \sin \varphi \sin \theta$

$$z' = r \cos \theta \qquad (1)$$

wherein said first support (P_1) being capable of being driven to change position in 3D space by driver and said second support (P_2) being capable of being driven to change position in 3D space or 2D plane relative to said first support (P_1) by driver, said robot has said robotic equipment mounted on said axial rod (R); and the length of the axial rod (R) should be longer than the maximum length of r, and

wherein a motion of said first support (P_1) relative to said axial rod (R) along of said axial rod (R) is constrained, and said second support (P_2) can travel along said axial rod (R) to enable to position and to direct said axial rod (R) and said robotic equipment,

wherein:

r: distance between p_1 and P2 along the axis of axial rod (R)

x_2: coordinate value of P_2 along the x axis of xyz coordinate

y_2: coordinate value of p_2 along the y axis of xyz coordinate

z_2: coordinate value of p_2 along the z axis of xyz coordinate

x_1: coordinate value of p_1 along the x axis of xyz coordinate

y_1: coordinate value of p_1 along the y axis of xyz coordinate

z_1: coordinate value of p_1 along the z axis of xyz coordinate

θ: angle of R measured from x axis of x-z plane

Φ: angle of R measured from y axis of y-z plane

$x' = x_2 = x_1$

$Y' = Y_2 - Y_1$

$z' = z_2 - z_1$

$r^2 = x'^2 + y'^2 + z'^2$

17. (currently amended) Robotic apparatus comprising a link mechanism with a first manipulator and a second manipulator connected to the link mechanism to determine the position and direction of a surgical assist apparatus in the presence of an electromagnetic field of magnetic resonance and therapy equipment, ~~wherein each of said manipulators has a configuration to minimize magnetic susceptibility and electrical noise radiation,~~ the link mechanism comprising:

an axial rod; and

two spherical bearings engaging with said axial rod, a second bearing of said two spherical bearings being capable of changing positions relative to a first bearing of said two spherical bearings along said axial rod, wherein said first manipulator extends from said first of said spherical bearings and said second manipulator extends from said second of said spherical bearings to engage the surgical assist apparatus while minimizing interaction with said electromagnetic field; and

wherein a motion of said first spherical bearing relative to said axial rod along an axis of said axial rod is constrained, and said second spherical bearing can travel along said rod to enable a drive mechanism to position and to direct each of said first and said second manipulators; and

wherein said rod and each of said spherical bearings constructed of material drawn from a class of paramagnetic materials of small magnetic susceptibility including ceramic material, glass fiber-reinforced material, carbon fiber reinforced material, wood, and non-ferrous metal, said material permitting use of the robot for magnetic resonance and therapy applications in an environment of an electromagnetic field without generation of artifacts in images produced by magnetic resonance and therapy applications.